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(54) **CAMERA OPTICAL LENS**

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G02B 27/0025 (2013.01)

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G02B 13/0015; G02B 1/041
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See application file for complete search history.

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This patent is subject to a terminal disclaimer.

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G02B 9/62 (2006.01)
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G02B 27/00 (2006.01)
G02B 13/18 (2006.01)

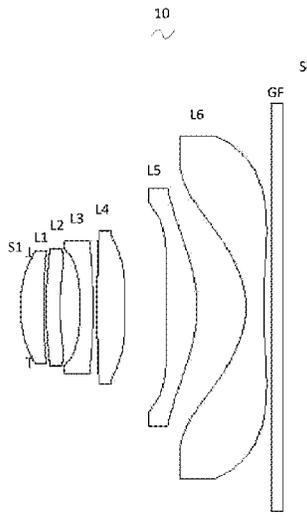
(57) **ABSTRACT**

The present disclosure discloses a camera optical lens. The camera optical lens includes, in an order from an object side to an image side, a first lens, a second lens, a third lens, a fourth lens, a fifth lens, and a sixth lens. The camera optical lens further satisfies specific conditions.

(52) **U.S. Cl.**

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21 Claims, 7 Drawing Sheets



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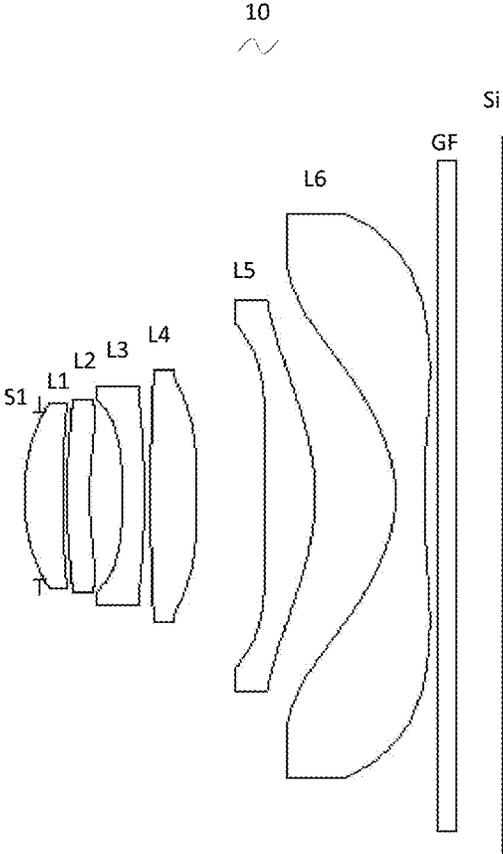


Fig. 1

Longitudinal aberration

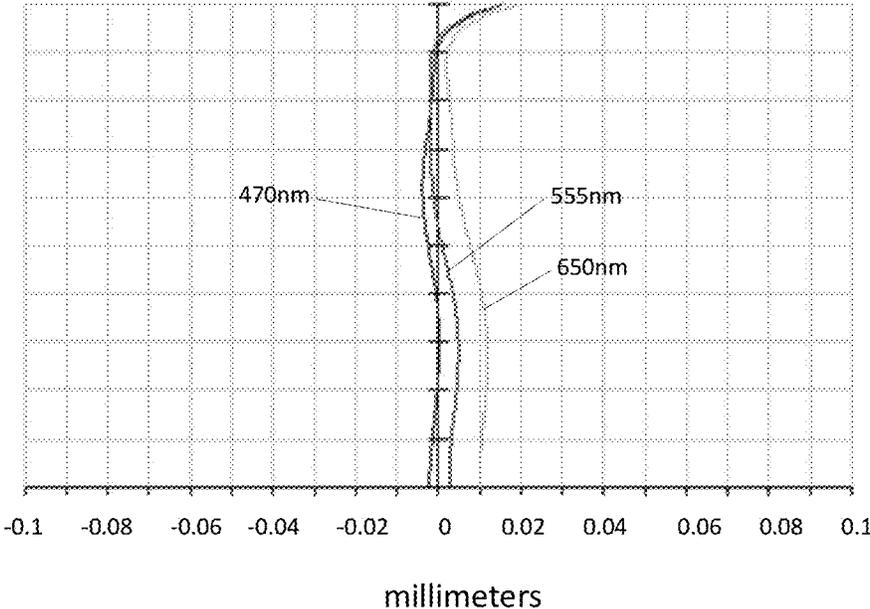


Fig. 2

Lateral color

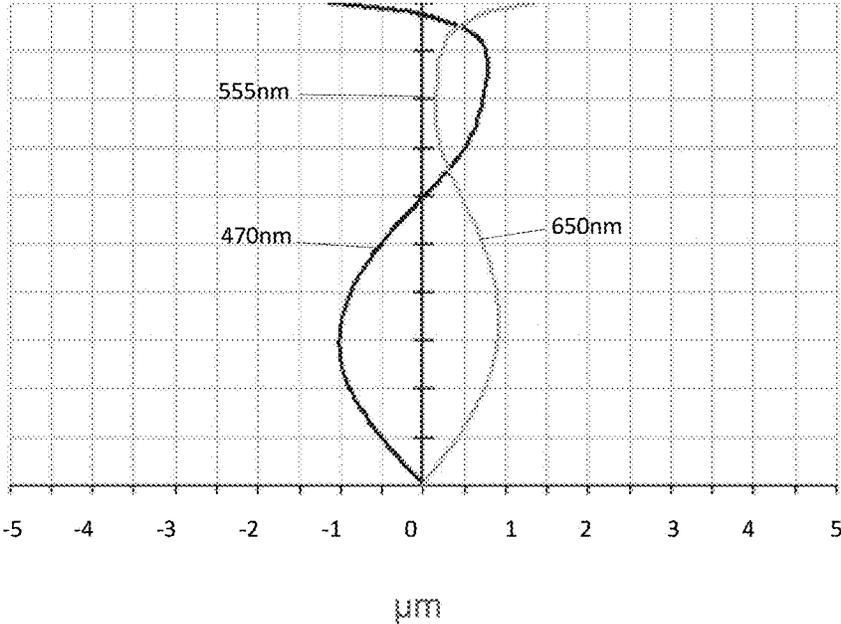


Fig. 3

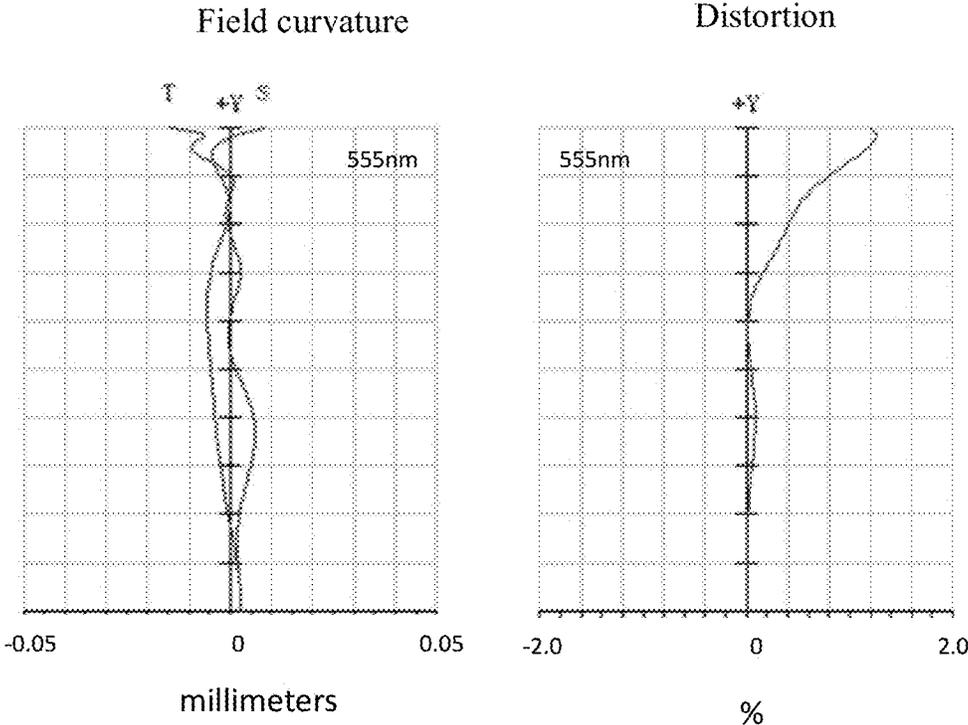


Fig. 4

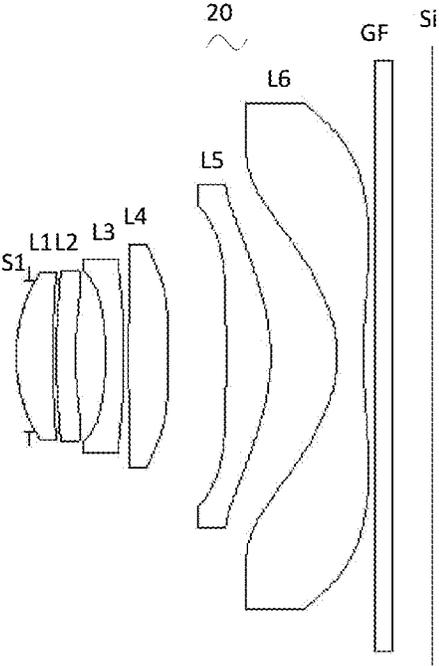


Fig. 5

Longitudinal aberration

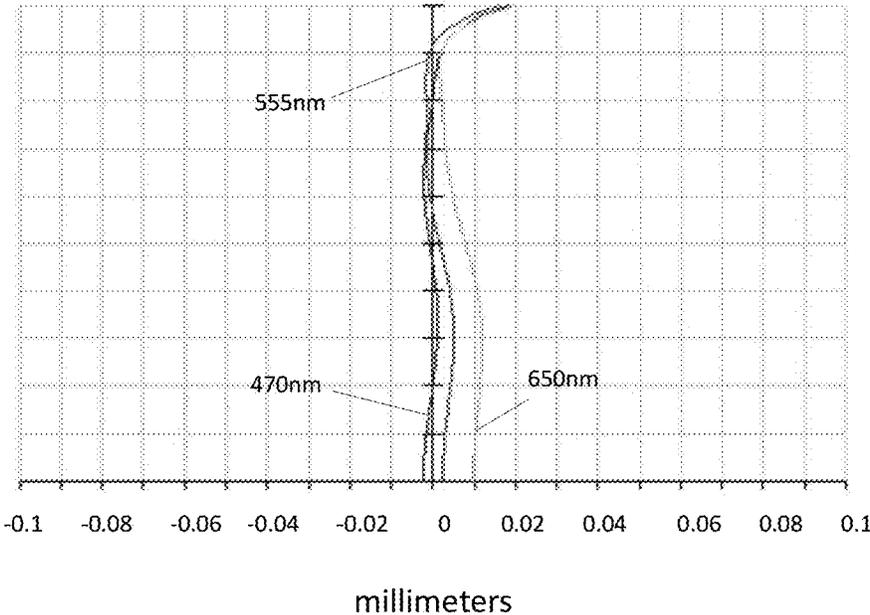


Fig. 6

Lateral color

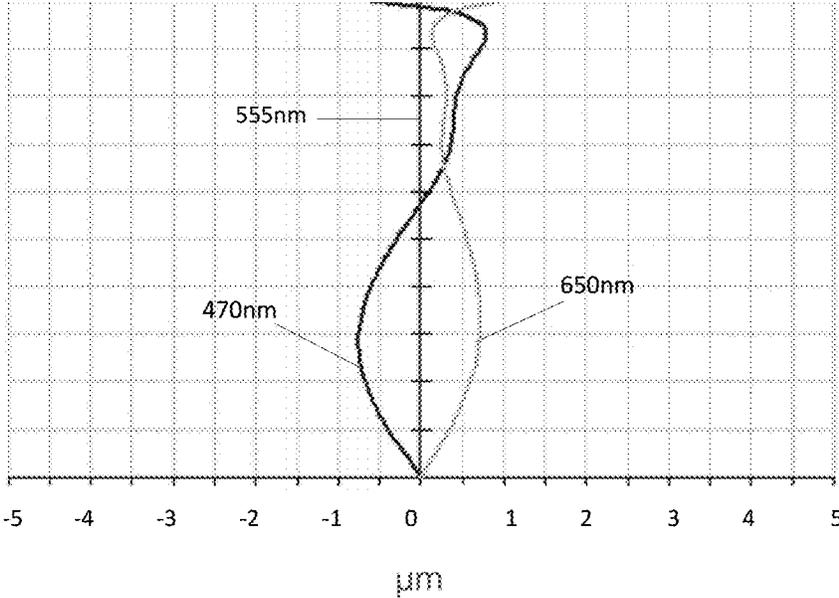


Fig. 7

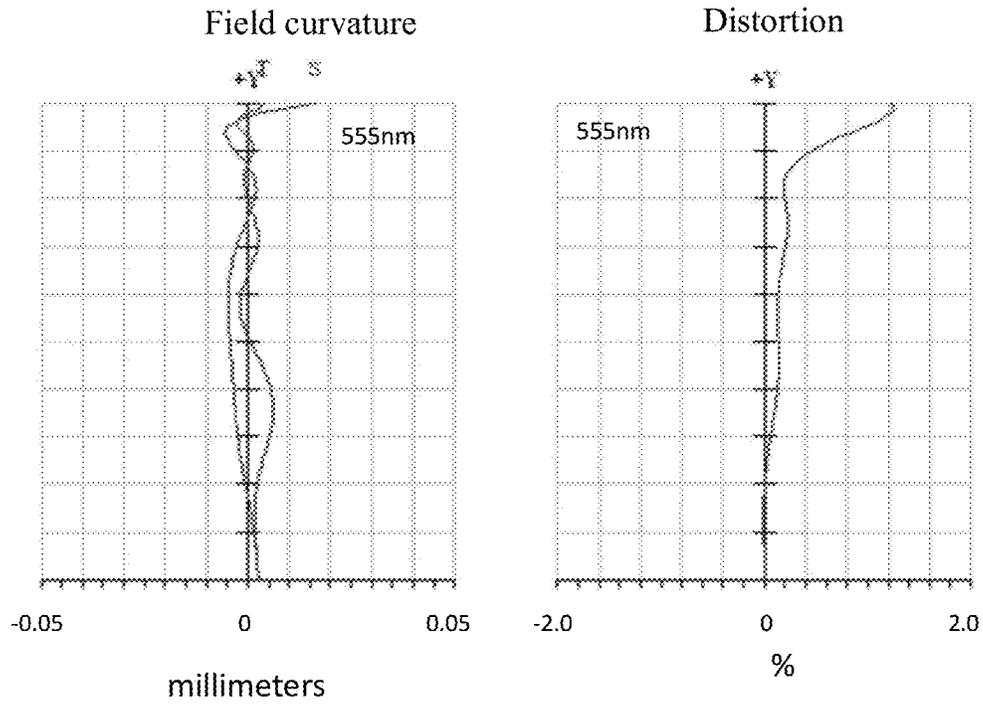


Fig. 8

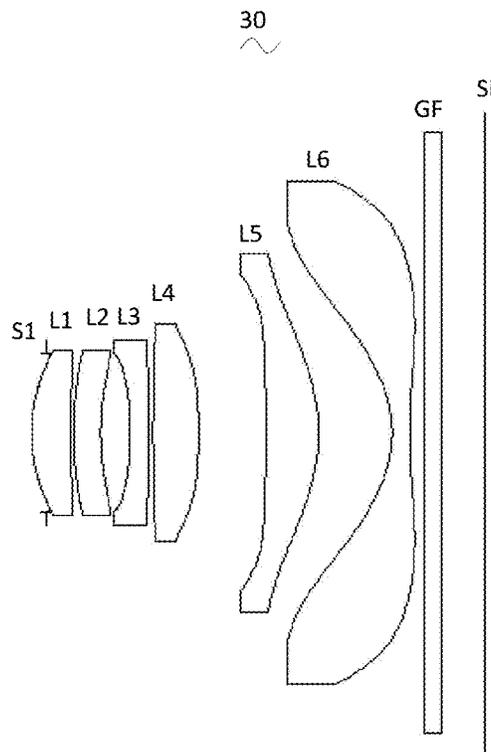


Fig. 9

Longitudinal aberration

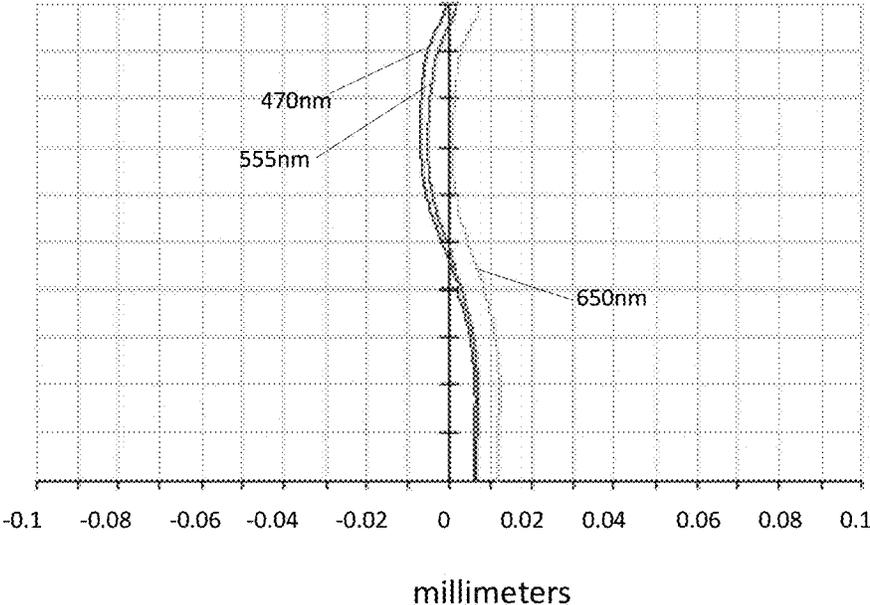


Fig. 10

Lateral color

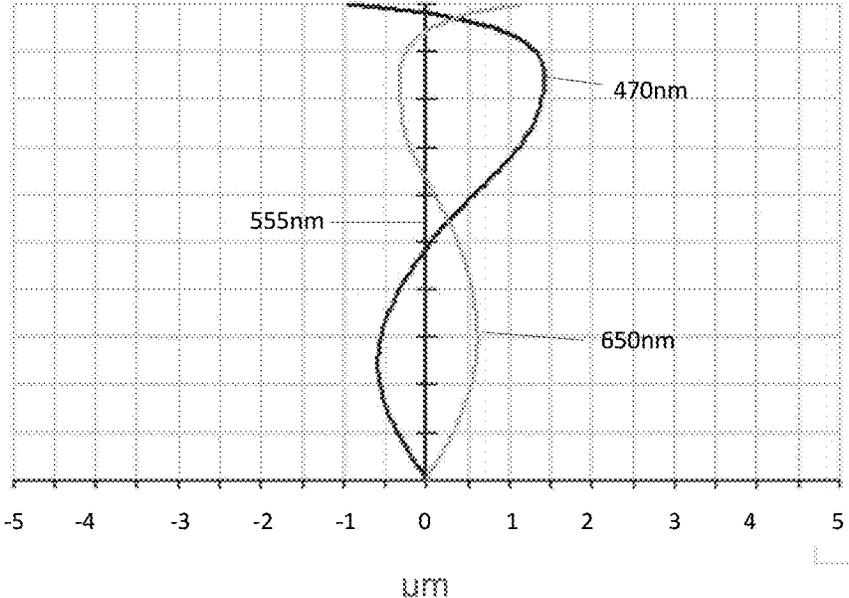


Fig. 11

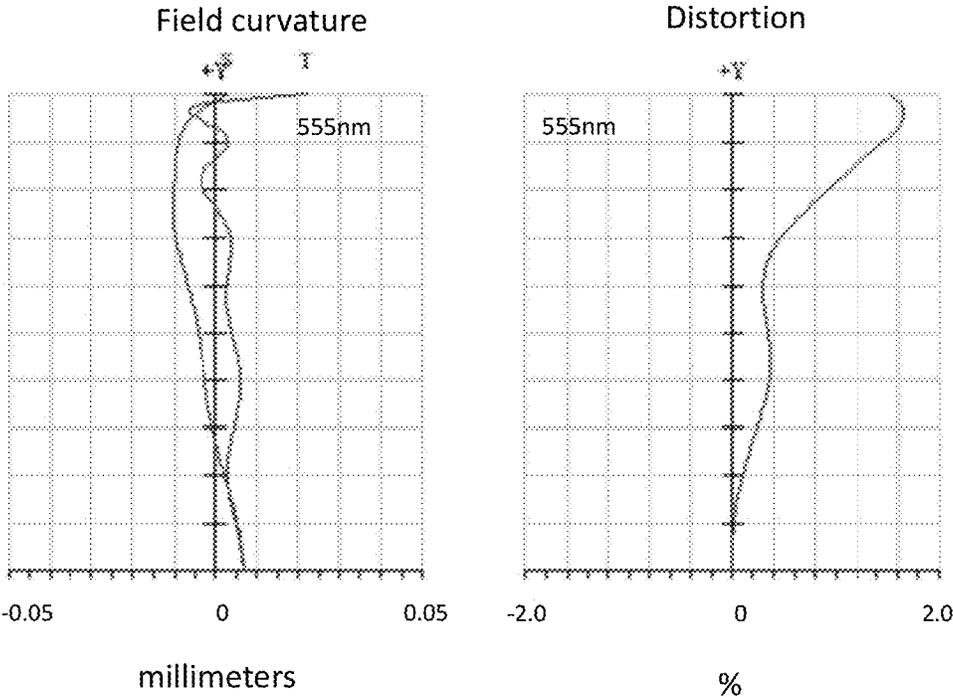


Fig. 12

CAMERA OPTICAL LENS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the priority benefit of Chinese Patent Applications Ser. No. 201810388561.1 and Ser. No. 201810388548.6 filed on Apr. 26, 2018, the entire content of which is incorporated herein by reference.

FIELD OF THE PRESENT DISCLOSURE

The present disclosure relates to optical lens, in particular to a camera optical lens suitable for handheld devices such as smart phones and digital cameras and imaging devices.

DESCRIPTION OF RELATED ART

With the emergence of smart phones in recent years, the demand for miniature camera lens is increasing day by day, but the photosensitive devices of general camera lens are no other than Charge Coupled Device (CCD) or Complementary Metal-Oxide Semiconductor Sensor (CMOS sensor), and as the progress of the semiconductor manufacturing technology makes the pixel size of the photosensitive devices shrink, coupled with the current development trend of electronic products being that their functions should be better and their shape should be thin and small, miniature camera lens with good imaging quality therefor has become a mainstream in the market. In order to obtain better imaging quality, the lens that is traditionally equipped in mobile phone cameras adopts a three-piece or four-piece lens structure. And, with the development of technology and the increase of the diverse demands of users, and under this circumstances that the pixel area of photosensitive devices is shrinking steadily and the requirement of the system for the imaging quality is improving constantly, the five-piece, six-piece and seven-piece lens structure gradually appear in lens design. There is an urgent need for ultra-thin wide-angle camera lenses which have good optical characteristics and the chromatic aberration of which is fully corrected.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the exemplary embodiments can be better understood with reference to the following drawings. The components in the drawing are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present disclosure.

FIG. 1 is a schematic diagram of a camera optical lens in accordance with a first embodiment of the present invention;

FIG. 2 shows the longitudinal aberration of the camera optical lens shown in FIG. 1;

FIG. 3 shows the lateral color of the camera optical lens shown in FIG. 1;

FIG. 4 presents a schematic diagram of the field curvature and distortion of the camera optical lens shown in FIG. 1;

FIG. 5 is a schematic diagram of a camera optical lens in accordance with a second embodiment of the present invention;

FIG. 6 presents the longitudinal aberration of the camera optical lens shown in FIG. 5;

FIG. 7 presents the lateral color of the camera optical lens shown in FIG. 5;

FIG. 8 presents the field curvature and distortion of the camera optical lens shown in FIG. 5;

FIG. 9 is a schematic diagram of a camera optical lens in accordance with a third embodiment of the present invention;

FIG. 10 presents the longitudinal aberration of the camera optical lens shown in FIG. 9;

FIG. 11 presents the lateral color of the camera optical lens shown in FIG. 9;

FIG. 12 presents the field curvature and distortion of the camera optical lens shown in FIG. 9.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

The present disclosure will hereinafter be described in detail with reference to several exemplary embodiments. To make the technical problems to be solved, technical solutions and beneficial effects of the present disclosure more apparent, the present disclosure is described in further detail together with the figure and the embodiments. It should be understood the specific embodiments described hereby is only to explain the disclosure, not intended to limit the disclosure.

Embodiment 1

As referring to FIG. 1, the present invention provides a camera optical lens 10. FIG. 1 shows the camera optical lens 10 of embodiment 1 of the present invention, the camera optical lens 10 comprises six lenses. Specifically, from the object side to the image side, the camera optical lens 10 comprises in sequence: an aperture S1, a first lens L1, a second lens L2, a third lens L3, a fourth lens L4, a fifth lens L5, and a sixth lens L6. Optical element like optical filter GF can be arranged between the sixth lens L6 and the image surface Si.

The first lens L1 is made of plastic material, the second lens L2 is made of glass material, the third lens L3 is made of plastic material, the fourth lens L4 is made of plastic material, the fifth lens L5 is made of glass material, the sixth lens L6 is made of plastic material. The second lens L2 has a negative refractive power and the third lens L3 has a negative refractive power.

Here, the focal length of the camera optical lens 10 is defined as f , the focal length of the first lens is defined as f_1 , the refractive index of the second lens is defined as n_2 , the refractive index of the fifth lens is defined as n_5 , the thickness on-axis of the second lens L2 is defined as d_3 and the total optical length of the camera optical lens is defined as TTL. The camera optical lens 10 satisfies the following conditions: $0.5 \leq f_1/f \leq 5$, $1.7 \leq n_2 \leq 2.2$, $1.7 \leq n_5 \leq 2.2$, $0.03 \leq d_3/TTL \leq 0.15$.

Condition $0.5 \leq f_1/f \leq 5$ fixes the positive refractive power of the first lens L1. If the lower limit of the set value is exceeded, although it benefits the ultra-thin development of lenses, but the positive refractive power of the first lens L1 will be too strong, problem like aberration is difficult to be corrected, and it is also unfavorable for wide-angle development of lens. On the contrary, if the upper limit of the set value is exceeded, the positive refractive power of the first lens becomes too weak, it is then difficult to develop ultra-thin lenses. Preferably, the following condition shall be satisfied, $0.785 \leq f_1/f \leq 3.09$.

Condition $1.75 \leq n_2 \leq 2.2$ fixes the refractive index of the second lens L2, refractive index within this range benefits the ultra-thin development of lenses, and it also benefits the correction of aberration. Preferably, the following condition shall be satisfied, $1.754 \leq n_2 \leq 2.062$.

Condition $1.75 \leq n_5 \leq 2.2$ fixes the refractive index of the fifth lens L5, refractive index within this range benefits the ultra-thin development of lenses, and it also benefits the correction of aberration. Preferably, the following condition shall be satisfied, $1.707 \leq n_5 \leq 1.978$.

Condition $0.03 \leq d_3/TTL \leq 0.15$ fixes the ratio between the thickness on-axis d_3 of the second lens L2 and the total optical length TTL of the camera optical lens, and it benefits the ultra-thin development of lenses. Preferably, the following condition shall be satisfied, $0.038 \leq d_3/TTL \leq 0.106$.

When the focal length of the camera optical lens 10 of the present invention, the focal length of each lens, the refractive index of the related lens, and the total optical length, the thickness on-axis and the curvature radius of the camera optical lens satisfy the above conditions, the camera optical lens 10 has the advantage of high performance and satisfies the design requirement of low TTL.

In this embodiment, the object side surface of the first lens L1 is a convex surface relative to the proximal axis, its image side surface is a concave surface relative to the proximal axis, and it has positive refractive power; the curvature radius of the object side surface of the first lens is defined as R1, the curvature radius of the image side surface of the first lens is defined as R2, the thickness on-axis of the first lens L1 is defined as d1 and the total optical length of the camera optical lens is defined as TTL, the condition $-3.014 \leq (R1+R2)/(R1-R2) \leq -0.97$ fixes the shape of the first lens L1, so that the first lens L1 can effectively correct system spherical aberration; when the condition $0.04 \leq d1/TTL \leq 0.13$ is met, it is beneficial for the realization of ultra-thin lenses. Preferably, the following conditions shall be satisfied: $-1.88 \leq (R1+R2)/(R1-R2) \leq -1.21$; $0.07 \leq d1/TTL \leq 0.11$.

In this embodiment, the object side surface of the second lens L2 is a convex surface relative to the proximal axis, and its image side surface is a concave surface relative to the proximal axis; the focal length of the camera optical lens 10 is defined as f, the focal length of the second lens L2 is defined as f2, the curvature radius of the object side surface of the second lens L2 is defined as R3, the curvature radius of image side surface of the second lens L2 is defined as R4, the thickness on-axis of the second lens L2 is defined as d3 and the total optical length of the camera optical lens is defined as TTL, they satisfy the following condition: $-10.59 \leq f_2/f \leq -2.53$, when the condition is met, the negative refractive power of the second lens L2 is controlled within reasonable scope, the spherical aberration caused by the first lens L1 which has positive refractive power and the field curvature of the system then can be reasonably and effectively balanced; the condition $2.73 \leq (R3+R4)/(R3-R4) \leq 12.93$ fixes the shape of the second lens L2, when value is beyond this range, with the development into the direction of ultra-thin and wide-angle lenses, problem like on-axis chromatic aberration is difficult to be corrected. Preferably, the following conditions shall be satisfied: $-6.62 \leq f_2/f \leq -3.16$; $4.36 \leq (R3+R4)/(R3-R4) \leq 10.34$.

In this embodiment, the object side surface of the third lens L3 is a concave surface relative to the proximal axis, and its image side surface is a convex surface relative to the proximal axis; the focal length of the camera optical lens 10 is defined as f, the focal length of the third lens L3 is defined as f3, the curvature radius of the object side surface of the third lens L3 is defined as R5, the curvature radius of the image side surface of the third lens L3 is defined as R6, the thickness on-axis of the third lens L3 is defined as d5 and the total optical length of the camera optical lens is defined as TTL, they satisfy the following condition: $-4.66 \leq$

$f_3/f \leq -1.27$, when the condition is met, the negative refractive power of the third lens L3 is controlled within reasonable scope, the spherical aberration caused by the second lens L2 which has negative refractive power and the field curvature of the system then can be reasonably and effectively balanced; the condition $-4.07 \leq (R5+R6)/(R5-R6) \leq -0.83$ fixes the shape of the third lens L3, when value is beyond this range, with the development into the direction of ultra-thin and wide-angle lenses, problem like on-axis chromatic aberration is difficult to be corrected; when the condition $0.02 \leq d_5/TTL \leq 0.07$ is met, it is beneficial for the realization of ultra-thin lenses. Preferably, the following conditions shall be satisfied: $-2.91 \leq f_3/f \leq -1.58$; $-2.55 \leq (R5+R6)/(R5-R6) \leq 1.04$; $0.03 \leq d_5/TTL \leq 0.05$.

In this embodiment, the object side surface of the fourth lens L4 is a convex surface relative to the proximal axis, its image side surface is a concave surface relative to the proximal axis, and it has positive refractive power; the focal length of the camera optical lens 10 is defined as f, the focal length of the fourth lens L4 is defined as f4, the curvature radius of the object side surface of the fourth lens L4 is defined as R7, the curvature radius of the image side surface of the fourth lens L4 is defined as R8, the thickness on-axis of the fourth lens L4 is defined as d7 and the total optical length of the camera optical lens is defined as TTL, they satisfy the condition: $0.85 \leq f_4/f \leq 2.91$, the appropriate distribution of refractive power makes it possible that the system has better imaging quality and lower sensitivity; the condition $-0.72 \leq (R7+R8)/(R7-R8) \leq -0.10$ fixes the shape of the fourth lens L4, when beyond this range, with the development into the direction of ultra-thin and wide-angle lens, the problem like chromatic aberration is difficult to be corrected; when the condition $0.05 \leq d_7/TTL \leq 0.15$ is met, it is beneficial for realization of ultra-thin lenses. Preferably, the following conditions shall be satisfied: $1.35 \leq f_4/f \leq 2.33$; $-0.45 \leq (R7+R8)/(R7-R8) \leq -0.12$; $0.08 \leq d_7/TTL \leq 0.12$.

In this embodiment, the object side surface of the fifth lens L5 is a concave surface relative to the proximal axis, its image side surface is a convex surface relative to the proximal axis, and it has positive refractive power; the focal length of the camera optical lens 10 is defined as f, the focal length of the fifth lens L5 is defined as f5, the curvature radius of the object side surface of the fifth lens L5 is defined as R9, the curvature radius of the image side surface of the fifth lens L5 is defined as R10, the thickness on-axis of the fifth lens L5 is defined as d9 and the total optical length of the camera optical lens is defined as TTL, they satisfy the condition: $0.41 \leq f_5/f \leq 1.28$, the limitation on the fifth lens L5 can effectively make the light angle of the camera lens flat and the tolerance sensitivity reduces; the condition $0.52 \leq (R9+R10)/(R9-R10) \leq 1.60$ fixes the shape of the fifth lens L5, when beyond this range, with the development into the direction of ultra-thin and wide-angle lens, the problem like off-axis chromatic aberration is difficult to be corrected; when the condition $0.05 \leq d_9/TTL \leq 0.18$ is met, it is beneficial for the realization of ultra-thin lens. Preferably, the following conditions shall be satisfied: $0.65 \leq f_5/f \leq 1.02$; $0.83 \leq (R9+R10)/(R9-R10) \leq 1.28$; $0.08 \leq d_9/TTL \leq 0.14$.

In this embodiment, the object side surface of the sixth lens L6 is a concave surface relative to the proximal axis, its image side surface is a concave surface relative to the proximal axis, and it has negative refractive power; the focal length of the camera optical lens 10 is defined as f, the focal length of the sixth lens L6 is defined as f6, the curvature radius of the object side surface of the sixth lens L6 is defined as R11, the curvature radius of the image side surface of the sixth lens L6 is defined as R12, the thickness

on-axis of the sixth lens L6 is defined as d11 and the total optical length of the camera optical lens is defined as TTL, they satisfy the condition: $-1.19 \leq f_6/f \leq -0.38$, the appropriate distribution of refractive power makes it possible that the system has better imaging quality and lower sensitivity; the condition $-1.24 \leq (R11+R12)/(R11-R12) \leq -0.41$ fixes the shape of the sixth lens L6, when beyond this range, with the development into the direction of ultra-thin and wide-angle lenses, the problem like off-axis chromatic aberration is difficult to be corrected; when the condition $0.02 \leq d11/TTL \leq 0.10$, is met, it is beneficial for the realization of ultra-thin lens. Preferably, the following conditions shall be satisfied, $-0.75 \leq f_6/f \leq -0.48$; $-0.78 \leq (R11+R12)/(R11-R12) \leq -0.51$; $0.03 \leq d11/TTL \leq 0.08$.

In this embodiment, the focal length of the camera optical lens 10 is defined as f and the combined focal length of the first lens and the second lens is defined as f12, when the condition $0.69 \leq f12/f \leq 2.12$ is met, the aberration and distortion of the camera lens can be eliminated, and the back focus of the camera lens can be suppressed and the miniaturization characteristics can be maintained. Preferably, the following conditions shall be satisfied: $1.11 \leq f12/f \leq 1.69$.

In this embodiment, the total optical length TTL of the camera optical lens 10 is less than or equal to 5.74 mm, it is beneficial for the realization of ultra-thin lenses. Preferably, the total optical length TTL of the camera optical lens 10 is less than or equal to 5.48 mm.

In this embodiment, the aperture F number of the camera optical lens 10 is less than or equal to 2.27. A large aperture has better imaging performance. Preferably, the aperture F number of the camera optical lens 10 is less than or equal to 2.22.

With such design, the total optical length TTL of the camera optical lens 10 can be made as short as possible, thus the miniaturization characteristics can be maintained.

In the following, an example will be used to describe the camera optical lens 10 of the present invention. The symbols recorded in each example are as follows. The unit of focal length, distance on-axis, curvature radius, thickness on-axis, inflexion point position and arrest point position is mm.

TTL: Optical length (the distance on-axis from the object side surface to the image surface of the first lens L).

Preferably, inflexion points and/or arrest points can also be arranged on the object side surface and/or image side surface of the lens, so that the demand for high quality imaging can be satisfied, the description below can be referred for specific implementable scheme.

The design information of the camera optical lens 10 in the first embodiment of the present invention is shown in the tables 1 and 2.

TABLE 1

	R	d	nd	vd
S1	∞	d0=	-0.160	
R1	2.103	d1=	0.422	nd1 1.5449 v1 55.93
R2	11.082	d2=	0.040	
R3	4.995	d3=	0.250	nd2 1.8081 v2 22.76
R4	3.787	d4=	0.361	
R5	-4.088	d5=	0.230	nd3 1.6713 v3 19.24
R6	-14.958	d6=	0.057	
R7	6.197	d7=	0.513	nd4 1.5352 v4 56.09
R8	-10.418	d8=	0.741	
R9	-124.727	d9=	0.539	nd5 1.7550 v5 52.32
R10	-2.531	d10=	0.870	
R11	-1.611	d11=	0.310	nd6 1.5352 v6 56.09
R12	6.684	d12=	0.140	
R13	∞	d13=	0.210	ndg 1.5168 vg 64.17
R14	∞	d14=	0.500	

In which, the meaning of the various symbols is as follows.

S1: Aperture;

R: The curvature radius of the optical surface, the central curvature radius in case of lens;

R1: The curvature radius of the object side surface of the first lens L1;

R2: The curvature radius of the image side surface of the first lens L1;

R3: The curvature radius of the object side surface of the second lens L2;

R4: The curvature radius of the image side surface of the second lens L2;

R5: The curvature radius of the object side surface of the third lens L3;

R6: The curvature radius of the image side surface of the third lens L3;

R7: The curvature radius of the object side surface of the fourth lens L4;

R8: The curvature radius of the image side surface of the fourth lens L4;

R9: The curvature radius of the object side surface of the fifth lens L5;

R10: The curvature radius of the image side surface of the fifth lens L5;

R11: The curvature radius of the object side surface of the sixth lens L6;

R12: The curvature radius of the image side surface of the sixth lens L6;

R13: The curvature radius of the object side surface of the optical filter GF;

R14: The curvature radius of the image side surface of the optical filter GF;

d: The thickness on-axis of the lens and the distance on-axis between the lens;

d0: The distance on-axis from aperture S1 to the object side surface of the first lens L1;

d1: The thickness on-axis of the first lens L1;

d2: The distance on-axis from the image side surface of the first lens L1 to the object side surface of the second lens L2;

d3: The thickness on-axis of the second lens L2;

d4: The distance on-axis from the image side surface of the second lens L2 to the object side surface of the third lens L3;

d5: The thickness on-axis of the third lens L3;

d6: The distance on-axis from the image side surface of the third lens L3 to the object side surface of the fourth lens L4;

d7: The thickness on-axis of the fourth lens L4;

d8: The distance on-axis from the image side surface of the fourth lens L4 to the object side surface of the fifth lens L5;

d9: The thickness on-axis of the fifth lens L5;

d10: The distance on-axis from the image side surface of the fifth lens L5 to the object side surface of the sixth lens L6;

d11: The thickness on-axis of the sixth lens L6;

d12: The distance on-axis from the image side surface of the sixth lens L6 to the object side surface of the optical filter GF;

d13: The thickness on-axis of the optical filter GF;

d14: The distance on-axis from the image side surface to the image surface of the optical filter GF;

nd: The refractive index of the d line;

nd1: The refractive index of the d line of the first lens L1;

nd2: The refractive index of the d line of the second lens L2;
 nd3: The refractive index of the d line of the third lens L3;
 nd4: The refractive index of the d line of the fourth lens L4;
 nd5: The refractive index of the d line of the fifth lens L5;
 nd6: The refractive index of the d line of the sixth lens L6;
 ndg: The refractive index of the d line of the optical filter GF;
 vd: The abbe number;
 v1: The abbe number of the first lens L1;
 v2: The abbe number of the second lens L2;
 v3: The abbe number of the third lens L3;
 v4: The abbe number of the fourth lens L4;
 v5: The abbe number of the fifth lens L5;
 v6: The abbe number of the sixth lens L6;
 vg: The abbe number of the optical filter GF;
 Table 2 shows the aspherical surface data of the camera optical lens in the embodiment 1 of the present invention.

TABLE 3

	inflexion point number	inflexion point position 1	inflexion point position 2	inflexion point position 3
5	P1R1	0		
	P1R2	0		
	P2R1	3	0.605	0.755
	P2R2	1	0.545	
10	P3R1	0		
	P3R2	1	1.035	
	P4R1	2	0.425	0.875
	P4R2	1	1.175	
	P5R1	0		
15	P5R2	2	1.335	2.085
	P6R1	1	1.555	
	P6R2	2	0.725	3.085

TABLE 2

	Conic Index		Aspherical Surface Index					
	k	A4	A6	A8	A10	A12	A14	A16
R1	-1.7929E-01	1.3099E-02	9.9201E-03	-1.3792E-02	1.7220E-02	-3.5382E-03	-2.1000E-03	1.1470E-03
R2	-1.7951E+02	3.3344E-03	-7.1599E-03	1.9310E-02	3.7410E-03	-1.1352E-02	1.6527E-02	-6.8587E-03
R3	-2.6186E+01	-3.1048E-02	-8.1356E-03	6.5674E-03	1.6064E-02	5.2109E-03	-1.0762E-02	-7.7927E-04
R4	9.3732E-01	-6.4047E-02	-1.7057E-02	-1.3505E-03	-1.0383E-02	6.8327E-05	1.3105E-02	-1.4049E-02
R5	7.8643E+00	-2.8098E-02	-3.2609E-02	-3.5477E-02	1.4053E-02	-1.5054E-02	-3.1913E-02	3.0383E-02
R6	1.1444E+02	-3.8867E-02	2.9828E-02	1.5190E-02	-2.0627E-02	3.7530E-03	-1.4163E-03	2.0450E-03
R7	-3.3457E+00	-9.8652E-02	5.4193E-02	-4.1661E-03	-2.9989E-03	-1.5439E-04	-1.6788E-04	3.3718E-04
R8	-1.9688E+01	-6.5172E-02	-1.0211E-02	-1.5124E-04	3.4897E-03	-2.5638E-04	2.6616E-04	2.3745E-04
R9	0.0000E+00	-1.0770E-02	2.8517E-03	-3.3271E-03	3.0881E-04	6.9965E-06	5.3976E-06	-2.9346E-07
R10	-2.1949E-01	2.2330E-02	4.9350E-03	-1.9495E-03	2.7827E-04	-1.7456E-06	-3.2947E-07	-2.7908E-07
R11	-3.0409E+00	-4.0261E-02	8.1762E-03	1.3152E-04	-6.5838E-05	-6.8082E-06	1.2044E-06	-3.5561E-08
R12	3.4701E+00	-3.0425E-02	3.6931E-03	-3.1970E-04	7.6228E-06	-4.4009E-06	8.1749E-07	-4.4218E-08

Among them, K is a conic index, A4, A6, A8, A10, A12, A14, A16 are aspheric surface indexes.

IH: Image height

$$y=(x^2/R)[1+\{(1-(k+1)(x^2/R^2)\}^{1/2}]+A4x^4+A6x^6+A8x^8+A10x^{10}+A12x^{12}+A14x^{14}+A16x^{16} \quad (1)$$

For convenience, the aspheric surface of each lens surface uses the aspheric surfaces shown in the above condition (1). However, the present invention is not limited to the aspherical polynomials form shown in the condition (1).

Table 3 and table 4 show the inflexion points and the arrest point design data of the camera optical lens 10 lens in embodiment 1 of the present invention. In which, P1R1 and P1R2 represent respectively the object side surface and image side surface of the first lens L1, P2R1 and P2R2 represent respectively the object side surface and image side surface of the second lens L2, P3R1 and P3R2 represent respectively the object side surface and image side surface of the third lens L3, P4R1 and P4R2 represent respectively the object side surface and image side surface of the fourth lens L4, P5R1 and P5R2 represent respectively the object side surface and image side surface of the fifth lens L5, P6R1 and P6R2 represent respectively the object side surface and image side surface of the sixth lens L6. The data in the column named "inflexion point position" are the vertical distances from the inflexion points arranged on each lens surface to the optic axis of the camera optical lens 10. The data in the column named "arrest point position" are the vertical distances from the arrest points arranged on each lens surface to the optic axis of the camera optical lens 10.

TABLE 4

	arrest point number	arrest point position 1
40	P1R1	0
	P1R2	0
	P2R1	0
	P2R2	1
	P3R1	0
	P3R2	0
	P4R1	0
	P4R2	1
	P5R1	0
	P5R2	0
	P6R1	0
	P6R2	1

FIG. 2 and FIG. 3 show the longitudinal aberration and lateral color schematic diagrams after light with a wavelength of 470 nm, 555 nm and 650 nm passes the camera optical lens 10 in the first embodiment. FIG. 4 shows the field curvature and distortion schematic diagrams after light with a wavelength of 555 nm passes the camera optical lens 10 in the first embodiment, the field curvature S in FIG. 4 is a field curvature in the sagittal direction, T is a field curvature in the meridian direction.

Table 13 shows the various values of the examples 1, 2, 3 and the values corresponding with the parameters which are already specified in the conditions.

As shown in Table 13, the first embodiment satisfies the various conditions.

In this embodiment, the pupil entering diameter of the camera optical lens is 1.819 mm, the full vision field image

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height is 3.918 mm, the vision field angle in the diagonal direction is 88.15°, it has wide-angle and is ultra-thin, its on-axis and off-axis chromatic aberrations are fully corrected, and it has excellent optical characteristics.

Embodiment 2

Embodiment 2 is basically the same as embodiment 1, the meaning of its symbols is the same as that of embodiment 1, in the following, only the differences are described.

Table 5 and table 6 show the design data of the camera optical lens 20 in embodiment 2 of the present invention.

TABLE 5

	R	d	nd	vd
S1	∞	d0=	-0.160	
R1	1.988	d1=	0.460	nd1 1.5449 v1 55.93
R2	10.868	d2=	0.040	
R3	5.558	d3=	0.240	nd2 1.8467 v2 23.78
R4	3.836	d4=	0.377	
R5	-4.197	d5=	0.230	nd3 1.6713 v3 19.24
R6	-12.298	d6=	0.051	
R7	6.204	d7=	0.508	nd4 1.5352 v4 56.09
R8	-13.213	d8=	0.721	
R9	-75.909	d9=	0.562	nd5 1.7292 v5 54.68
R10	-2.435	d10=	0.832	
R11	-1.581	d11=	0.330	nd6 1.5352 v6 56.09
R12	6.752	d12=	0.145	
R13	∞	d13=	0.210	ndg 1.5168 vg 64.17
R14	∞	d14=	0.500	

Table 6 shows the aspherical surface data of each lens of the camera optical lens 20 in embodiment 2 of the present invention.

TABLE 6

	Conic Index		Aspherical Surface Index					
	k	A4	A6	A8	A10	A12	A14	A16
R1	-1.8773E-01	1.2693E-02	9.6660E-03	-1.7119E-02	1.7591E-02	-3.0751E-03	-2.0766E-03	1.2429E-03
R2	-3.3048E+02	-2.8903E-03	-4.0983E-03	2.4070E-02	-3.7959E-03	-1.1281E-02	1.3170E-02	4.8304E-04
R3	-4.9639E+01	-3.4433E-02	2.0383E-03	1.7004E-02	8.0982E-03	-5.9933E-03	-7.0486E-03	5.9386E-03
R4	1.0226E+00	-5.9675E-02	-9.7853E-03	9.9861E-03	-9.2276E-03	-8.5750E-03	6.3640E-03	-6.4455E-03
R5	1.0363E+01	-1.9045E-02	-3.1316E-02	-2.3479E-02	1.4615E-02	-1.3878E-02	-3.1766E-02	2.6242E-02
R6	8.2216E+01	-4.2619E-02	3.4179E-02	1.5345E-02	-1.9685E-02	3.8044E-03	-1.7892E-03	2.5831E-03
R7	-1.1574E+01	-1.0189E-01	5.4107E-02	-3.6651E-03	-3.1992E-03	-5.4095E-04	1.2970E-04	1.8537E-04
R8	-1.7946E+02	-6.9992E-02	-1.0870E-02	1.0753E-03	3.0857E-03	-4.7155E-04	-1.6694E-05	2.8988E-04
R9	0.0000E+00	-1.3625E-02	2.5404E-03	-3.6275E-03	3.8490E-04	-5.5357E-06	-1.1385E-06	4.1142E-06
R10	-2.3676E-01	2.1584E-02	4.4973E-03	-1.8748E-03	2.7940E-04	-1.4644E-06	1.3116E-07	-1.9393E-07
R11	-3.0676E+00	-4.0011E-02	8.2527E-03	1.2873E-04	-6.6127E-05	-7.2473E-06	1.3625E-06	-4.4176E-08
R12	3.5530E+00	-2.8654E-02	3.2705E-03	-2.7389E-04	4.7346E-06	-4.3730E-06	8.1137E-07	-4.0376E-08

Table 7 and table 8 show the inflexion points and the arrest point design data of the camera optical lens 20 lens in the second embodiment of the present invention.

TABLE 7

	inflexion point number	inflexion point position 1	inflexion point position 2
P1R1	0		
P1R2	0		
P2R1	2	0.615	0.645
P2R2	1	0.595	
P3R1	0		
P3R2	1	0.925	
P4R1	2	0.395	0.975
P4R2	1	1.205	
P5R1	1	1.785	

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TABLE 7-continued

	inflexion point number	inflexion point position 1	inflexion point position 2
P5R2	1	1.495	
P6R1	1	1.545	
P6R2	2	0.745	3.035

TABLE 8

	arrest point number	arrest point position 1	arrest point position 2
P1R1	0		
P1R2	0		
P2R1	0		
P2R2	1	0.915	
P3R1	0		
P3R2	1	1.145	
P4R1	2	0.875	1.075
P4R2	0		
P5R1	0		
P5R2	0		
P6R1	0		
P6R2	1	1.395	

FIG. 6 and FIG. 7 show the longitudinal aberration and lateral color schematic diagrams after light with a wavelength of 470 nm, 555 nm and 650 nm passes the camera optical lens 20 in the second embodiment. FIG. 8 shows the field curvature and distortion schematic diagrams after light with a wavelength of 555 nm passes the camera optical lens 20 in the second embodiment.

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As shown in Table 13, the second embodiment satisfies the various conditions.

In this embodiment, the pupil entering diameter of the camera optical lens is 1.858 mm, the full vision field image height is 3.918 mm, the vision field angle in the diagonal direction is 86.94°, it has wide-angle and is ultra-thin, its on-axis and off-axis chromatic aberrations are fully corrected, and it has excellent optical characteristics.

Embodiment 3

Embodiment 3 is basically the same as embodiment 1, the meaning of its symbols is the same as that of embodiment 1, in the following, only the differences are described.

The design information of the camera optical lens 30 in the third embodiment of the present invention is shown in the tables 9 and 10.

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TABLE 9

	R	d	nd	vd	
S1	∞	d0=	-0.160		
R1	2.115	d1=	0.445	nd1	1.5449 v1 55.93 5
R2	10.480	d2=	0.035		
R3	4.336	d3=	0.316	nd2	1.9229 v2 18.90
R4	3.435	d4=	0.339		
R5	-4.611	d5=	0.220	nd3	1.6713 v3 19.24
R6	-41.826	d6=	0.039		
R7	6.292	d7=	0.524	nd4	1.5352 v4 56.09 10
R8	-8.495	d8=	0.777		
R9	-74.606	d9=	0.611	nd5	1.7130 v5 53.87
R10	-2.288	d10=	0.845		
R11	-1.572	d11=	0.200	nd6	1.5352 v6 56.09
R12	6.488	d12=	0.158		
R13	∞	d13=	0.210	ndg	1.5168 vg 64.17 15
R14	∞	d14=	0.500		

Table 10 shows the aspherical surface data of each lens of the camera optical lens 30 in embodiment 3 of the present invention.

TABLE 10

	Conic Index	Aspherical Surface Index						
		k	A4	A6	A8	A10	A12	A14
R1	-3.6018E-01	4.2909E-03	1.0552E-02	-2.6527E-02	1.7872E-02	-4.3411E-03	-3.3914E-03	-1.1255E-03
R2	-1.8828E+02	-1.6692E-03	-3.6699E-03	1.0503E-02	-7.4447E-03	-9.7351E-03	5.7773E-04	-9.1222E-04
R3	-4.5291E+00	-1.7319E-02	1.0137E-02	1.0624E-02	2.0002E-03	-1.9855E-03	-4.2806E-03	1.6771E-03
R4	5.1184E+00	-3.8841E-02	-1.4928E-02	1.0579E-03	-1.3241E-03	-1.0821E-04	2.6934E-03	-5.6027E-03
R5	1.1034E+01	-8.9231E-03	-5.4317E-02	-2.0243E-03	5.9624E-03	-2.0639E-02	-2.3506E-02	2.8537E-02
R6	7.7467E+02	-5.0726E-02	3.7091E-02	1.2275E-02	-1.6895E-02	3.3354E-03	-3.8106E-03	2.9443E-03
R7	-4.8013E+01	-9.7499E-02	5.7043E-02	-1.4826E-03	-3.2649E-03	-4.3529E-04	-2.4672E-04	3.5355E-04
R8	-6.3898E+01	-6.7267E-02	-8.2723E-03	-2.5030E-03	2.9877E-03	3.7187E-04	4.6783E-04	1.9821E-04
R9	1.2904E+03	-7.4074E-03	2.9248E-03	-3.0280E-03	4.0447E-04	-2.4230E-05	-3.8451E-06	2.5956E-06
R10	-3.5915E-01	2.5086E-02	4.9275E-03	-1.8205E-03	2.4277E-04	-3.3853E-06	-1.7485E-07	-1.0460E-07
R11	-2.9711E+00	-3.7146E-02	7.7038E-03	1.1595E-04	-6.5469E-05	-7.8017E-06	1.5860E-06	-6.1988E-08
R12	3.1865E+00	-3.2575E-02	3.9211E-03	-3.2150E-04	7.8329E-06	-4.0012E-06	7.1181E-07	-3.7893E-08

Table 11 and table 12 show the inflexion points and the arrest point design data of the camera optical lens 30 lens in embodiment 3 of the present invention.

TABLE 11

	inflexion point number	inflexion point position 1	inflexion point position 2
P1R1	1	0.965	
P1R2	1	0.695	
P2R1	0		
P2R2	1	0.815	
P3R1	0		
P3R2	1	0.845	
P4R1	2	0.375	0.865
P4R2	1	1.155	
P5R1	1	1.885	
P5R2	1	1.325	
P6R1	1	1.555	
P6R2	2	0.705	3.085

TABLE 12

	arrest point number	arrest point position 1	arrest point position 2
P1R1	0		
P1R2	1	0.925	
P2R1	0		
P2R2	0		
P3R1	0		

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TABLE 12-continued

	arrest point number	arrest point position 1	arrest point position 2
P3R2	0		
P4R1	2	0.825	0.895
P4R2	0		
P5R1	0		
P5R2	0		
P6R1	0		
P6R2	1	1.325	

FIG. 10 and FIG. 11 show the longitudinal aberration and lateral color schematic diagrams after light with a wavelength of 470 nm, 555 nm and 650 nm passes the camera optical lens 30 in the third embodiment. FIG. 12 shows the field curvature and distortion schematic diagrams after light with a wavelength of 555 nm passes the camera optical lens 30 in the third embodiment.

The following table 13, in accordance with the above conditions, lists the values in this embodiment correspond-

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ing with each condition expression. Apparently, the camera optical system of this embodiment satisfies the above conditions.

In this embodiment, the pupil entering diameter of the camera optical lens is 1.920 mm, the full vision field image height is 3.918 mm, the vision field angle in the diagonal direction is 87.62°, it has wide-angle and is ultra-thin, its on-axis and off-axis chromatic aberrations are fully corrected, and it has excellent optical characteristics.

TABLE 13

	Embodiment 1	Embodiment 2	Embodiment 3
f	4.002	4.087	4.032
f1	4.671	4.370	4.757
f2	-21.181	-15.501	-21.350
f3	-8.374	-9.513	-7.667
f4	7.315	7.935	6.816
f5	3.404	3.427	3.288
f6	-2.387	-2.353	-2.336
f12	5.651	5.658	5.665
(R1 + R2)/(R1 - R2)	-1.469	-1.448	-1.506
(R3 + R4)/(R3 - R4)	7.266	5.453	8.620
(R5 + R6)/(R5 - R6)	-1.752	-2.036	-1.248
(R7 + R8)/(R7 - R8)	-0.254	-0.361	-0.149
(R9 + R10)/(R9 - R10)	1.041	1.066	1.063
(R11 + R12)/(R11 - R12)	-0.612	-0.621	-0.610
f1/f	1.167	1.069	1.180
f2/f	-5.293	-3.793	-5.295
f3/f	-2.092504639	-2.327774112	-1.901342566

TABLE 13-continued

	Embodiment 1	Embodiment 2	Embodiment 3
f4/f	1.828	1.942	1.690
f5/f	0.851	0.839	0.815
f6/f	-0.596	-0.576	-0.579
f12/f	1.412	1.384	1.405
d1	0.422	0.460	0.445
d3	0.250	0.240	0.316
d5	0.230	0.230	0.220
d7	0.513	0.508	0.524
d9	0.539	0.562	0.611
d11	0.310	0.330	0.200
Fno	2.200	2.200	2.100
TTL	5.182	5.206	5.220
d1/TTL	0.081	0.088	0.085
d3/TTL	0.048	0.046	0.061
d5/TTL	0.044	0.044	0.042
d7/TTL	0.099	0.098	0.100
d9/TTL	0.104	0.108	0.117
d11/TTL	0.060	0.063	0.038
n1	1.5449	1.5449	1.5449
n2	1.8081	1.8467	1.9229
n3	1.6713	1.6713	1.6713
n4	1.5352	1.5352	1.5352
n5	1.7550	1.7292	1.7130
n6	1.5352	1.5352	1.5352
v1	55.9299	55.9299	55.9299
v2	22.7608	23.7779	18.8969
v3	19.2429	19.2429	19.2429
v4	56.0934	56.0934	56.0934
v5	52.3214	54.6800	53.8671
v6	56.0934	56.0934	56.0934

It is to be understood, however, that even though numerous characteristics and advantages of the present exemplary embodiments have been set forth in the foregoing description, together with details of the structures and functions of the embodiments, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms where the appended claims are expressed.

What is claimed is:

1. A camera optical lens comprising, from an object side to an image side in sequence: a first lens, a second lens, a third lens, a fourth lens, a fifth lens and a sixth lens; wherein the second lens has a negative refractive power, the third lens has a negative refractive power; the camera optical lens further satisfies the following conditions:

$$0.5 \leq f1/f \leq 5;$$

$$1.7 \leq n2 \leq 2.2;$$

$$1.7 \leq n5 \leq 2.2;$$

$$0.03 \leq d3/TTL \leq 0.15;$$

where
 f: the focal length of the camera optical lens;
 f1: the focal length of the first lens;
 n2: the refractive index of the second lens;
 n5: the refractive index of the fifth lens;
 d3: the thickness on-axis of the second lens;
 TTL: the total optical length of the camera optical lens.

2. The camera optical lens as described in claim 1, wherein the first lens is made of plastic material, the second lens is made of glass material, the third lens is made of plastic material, the fourth lens is made of plastic material, the fifth lens is made of glass material, the sixth lens is made of plastic material.

3. The camera optical lens as described in claim 1, wherein the camera optical lens further satisfies the following conditions:

$$0.785 \leq f1/f \leq 3.09;$$

$$1.754 \leq n2 \leq 2.062;$$

$$1.707 \leq n5 \leq 1.978;$$

$$0.038 \leq d3/TTL \leq 0.106.$$

4. The camera optical lens as described in claim 1, wherein the first lens has a positive refractive power with a convex object side surface and a concave image side surface; the camera optical lens further satisfies the following conditions:

$$-3.01 \leq (R1+R2)/(R1-R2) \leq -0.97;$$

$$0.04 \leq d1/TTL \leq 0.13;$$

where
 R1: the curvature radius of object side surface of the first lens;

R2: the curvature radius of image side surface of the first lens;

d1: the thickness on-axis of the first lens;

TTL: the total optical length of the camera optical lens.

5. The camera optical lens as described in claim 4, wherein the camera optical lens further satisfies the following conditions:

$$-1.88 \leq (R1+R2)/(R1-R2) \leq -1.21;$$

$$0.07 \leq d1/TTL \leq 0.11.$$

6. The camera optical lens as described in claim 1, wherein the second lens has a convex object side surface and a concave image side surface; the camera optical lens further satisfies the following conditions:

$$-10.59 \leq f2/f \leq -2.53;$$

$$2.73 \leq (R3+R4)/(R3-R4) \leq 12.93;$$

where
 f: the focal length of the camera optical lens;

f2: the focal length of the second lens;

R3: the curvature radius of the object side surface of the second lens;

R4: the curvature radius of the image side surface of the second lens.

7. The camera optical lens as described in claim 6, wherein the camera optical lens further satisfies the following conditions:

$$-6.62 \leq f2/f \leq -3.16;$$

$$4.36 \leq (R3+R4)/(R3-R4) \leq 10.34.$$

8. The camera optical lens as described in claim 1, wherein the third lens has a concave object side surface and a convex image side surface; the camera optical lens further satisfies the following conditions:

$$-4.66 \leq f3/f \leq -1.27;$$

$$-4.07 \leq (R5+R6)/(R5-R6) \leq -0.83;$$

$$0.02 \leq d5/TTL \leq 0.07;$$

where
 f: the focal length of the camera optical lens;

f3: the focal length of the third lens;

R5: the curvature radius of the object side surface of the third lens;

R6: the curvature radius of the image side surface of the third lens;

d5: the thickness on-axis of the third lens;

TTL: the total optical length of the camera optical lens.

9. The camera optical lens as described in claim 8, wherein the camera optical lens further satisfies the following conditions:

$$-2.91 \leq f3/f \leq -1.58;$$

$$-2.55 \leq (R5+R6)/(R5-R6) \leq -1.04;$$

$$0.03 \leq d5/TTL \leq 0.05.$$

10. The camera optical lens as described in claim 1, wherein the fourth lens has a positive refractive power with a convex object side surface and a convex image side surface; the camera optical lens further satisfies the following conditions:

$$0.85 \leq f4/f \leq 2.91;$$

$$-0.72 \leq (R7+R8)/(R7-R8) \leq -0.10;$$

$$0.05 \leq d7/TTL \leq 0.15;$$

where
 f: the focal length of the camera optical lens;

f4: the focal length of the fourth lens;

R7: the curvature radius of the object side surface of the fourth lens;

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R8: the curvature radius of the image side surface of the fourth lens;
 d7: the thickness on-axis of the fourth lens;
 TTL: the total optical length of the camera optical lens.
11. The camera optical lens as described in claim 10, wherein the camera optical lens further satisfies the following conditions:
 $1.35 \leq f4/f \leq 2.23$;
 $-0.45 \leq (R7+R8)/(R7-R8) \leq -0.12$;
 $0.08 \leq d7/TTL \leq 0.12$.
12. The camera optical lens as described in claim 1, wherein the fifth lens has a positive refractive power with a concave object side surface and a convex image side surface; the camera optical lens further satisfies the following conditions:
 $0.41 \leq f5/f \leq 1.28$;
 $0.52 \leq (R9+R10)/(R9-R10) \leq 1.60$;
 $0.05 \leq d9/TTL \leq 0.18$; where
 f: the focal length of the camera optical lens;
 f5: the focal length of the fifth lens;
 R9: the curvature radius of the object side surface of the fifth lens;
 R10: the curvature radius of the image side surface of the fifth lens;
 d9: the thickness on-axis of the fifth lens;
 TTL: the total optical length of the camera optical lens.
13. The camera optical lens as described in claim 12, wherein the camera optical lens further satisfies the following conditions:
 $0.65 \leq f5/f \leq 1.02$;
 $0.83 \leq (R9+R10)/(R9-R10) \leq 1.28$;
 $0.08 \leq d9/TTL \leq 0.14$.
14. The camera optical lens as described in claim 1, wherein the sixth lens has a negative refractive power with a concave object side surface and a concave image side surface; the camera optical lens further satisfies the following conditions:
 $-1.19 \leq f6/f \leq -0.38$;
 $-1.24 \leq (R11+R12)/(R11-R12) \leq -0.41$;
 $0.02 \leq d11/TTL \leq 0.10$; where

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f: the focal length of the camera optical lens;
 f6: the focal length of the sixth lens;
 R11: the curvature radius of the object side surface of the sixth lens;
 R12: the curvature radius of the image side surface of the sixth lens;
 d11: the thickness on-axis of the sixth lens;
 TTL: the total optical length of the camera optical lens.
15. The camera optical lens as described in claim 14, wherein the camera optical lens further satisfies the following conditions:
 $-0.75 \leq f6/f \leq -0.48$;
 $-0.78 \leq (R11+R12)/(R11-R12) \leq -0.51$;
 $0.03 \leq d11/TTL \leq 0.08$.
16. The camera optical lens as described in claim 1, wherein the camera optical lens further satisfies the following conditions:
 $0.69 \leq f12/f \leq 2.12$; where
 f: the focal length of the camera optical lens;
 f12: the combined focal length of the first lens and the second lens.
17. The camera optical lens as described in claim 16, wherein the camera optical lens further satisfies the following conditions:
 $1.11 \leq f12/f \leq 1.69$.
18. The camera optical lens as described in claim 1, wherein the total optical length TTL of the camera optical lens is less than or equal to 5.74 mm.
19. The camera optical lens as described in claim 18, wherein the total optical length TTL of the camera optical lens is less than or equal to 5.48 mm.
20. The camera optical lens as described in claim 1, wherein the aperture F number of the camera optical lens is less than or equal to 2.27.
21. The camera optical lens as described in claim 20, wherein the aperture F number of the camera optical lens is less than or equal to 2.22.

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